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A Publication of The Wildlife Society

NEW PRINCIPLES FOR THE CONSERVATION OF WILD LIVING RESOURCES

by

SIDNEY J. HOLT AND LEE M. TALBOT

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WILDLIFE MONOGRAPHS

Louis A. Krumholz, *Editor*

Office of Academic Affairs, University of Louisville,
Louisville, Kentucky 40208

Consulting Editors for this Issue: **Each of the thirty-four participants listed in Appendix 1 reviewed the final draft of the manuscript, and each is considered to be a Consulting Editor**

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There is a perpetual need for additional funds to sponsor publication of worthwhile manuscripts in *Wildlife Monographs*. Any contribution will be accepted with gratitude by The Wildlife Society. Memorial funds collected to honor and perpetuate the names of deceased members of the profession probably could be put to no better use.

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APRIL 1978 NO. 59

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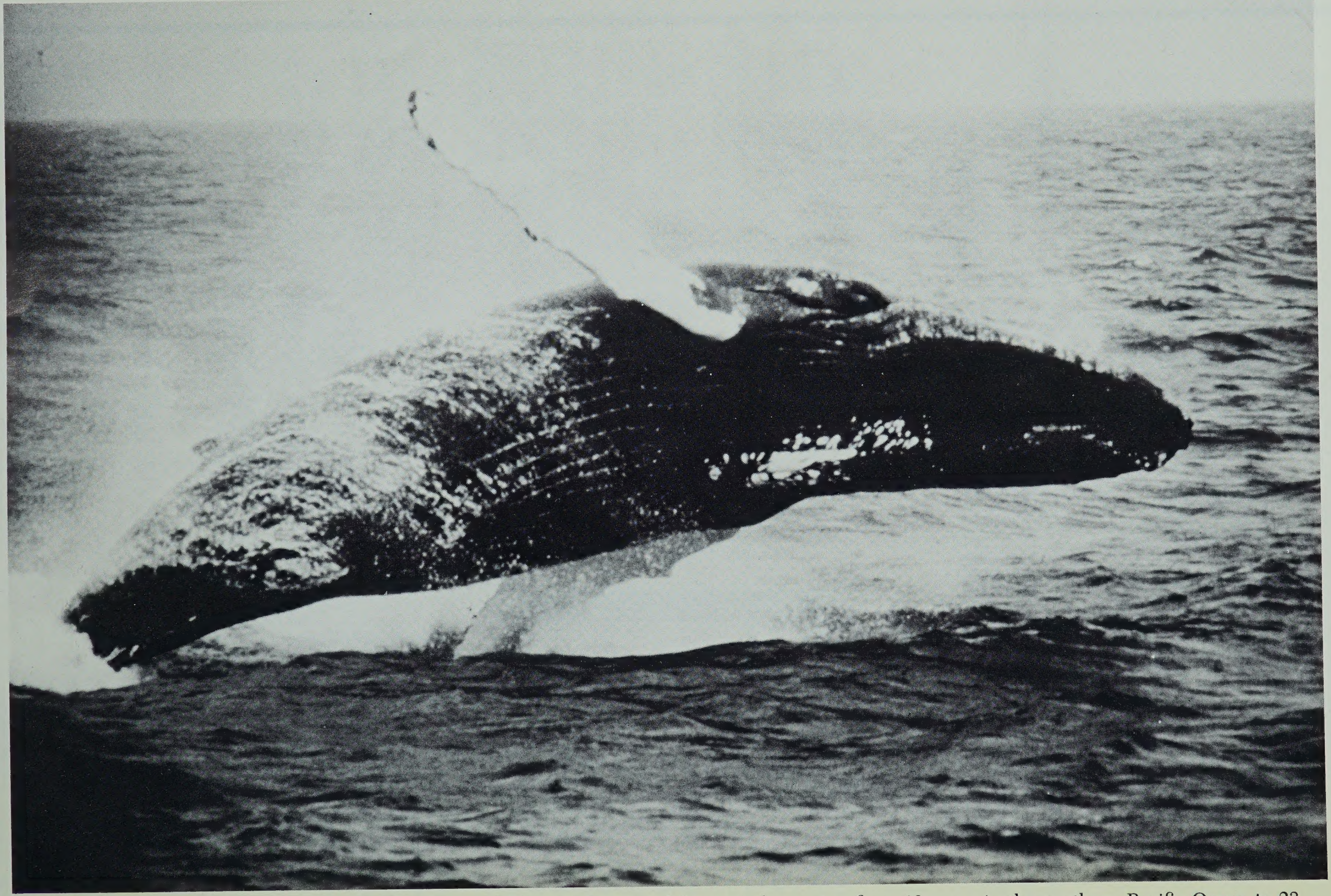

FRONTISPIECE. Humpback whale, Pacific Ocean off Hawaii. Protected for periods ranging from 12 years in the northern Pacific Ocean to 23 years in the northwestern Atlantic Ocean. The remaining humpback whale stocks are roughly estimated at about 10 percent of their original populations, with no clear evidence of recovery. Whales represent the classic case of mismanagement of wild living resources, one with stock after stock overharvested to commercial, and occasionally, biological extinction. However, the International Whaling Commission has now adopted most of the new principles for management that this paper recommends. (Credit: John Dominis, Time-Life Inc.)

NEW PRINCIPLES FOR THE CONSERVATION OF WILD LIVING RESOURCES

Sidney J. Holt[1] *and Lee M. Talbot*[2]

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[2] President's Council on Environmental Quality, Washington, D.C. 20006.

PREFACE

There is growing international concern with the depletion of stocks of many wild animal resources—fishes, marine mammals, reptiles, invertebrates, and terrestrial wildlife—in the face of increasing demands on those resources for food and other values. That concern led to development of a program to critically examine the basis for management of those resources and to prepare appropriate recommendations for improvement in their management. The program was sponsored by the President's Council on Environmental Quality, the World Wildlife Fund–U.S., the Ecological Society of America, the Smithsonian Institution, and the International Union for the Conservation of Nature and Natural Resources.

The financial support for the program and publication of this monograph was provided by the World Wildlife Fund–U.S., and very considerable secretarial and other staff assistance was furnished by the Washington Office of the Fund and the Council on Environmental Quality. The program was organized by Lee M. Talbot.

Preliminary consultations and meetings were held in 1974, followed by two workshops at Airlie House, Virginia, in February and April 1975. This report is the final result.

The participants in the workshops first critically reviewed the scientific basis of existing goals of conservation. They examined both the theory and the practice of aquatic and terrestrial wildlife management, insofar as it is directed to sustaining the values of resources for future realization on a continuing basis. They concluded that a new statement of principles was urgently needed to meet modern needs in the light of current knowledge, particularly of ecology. They prepared such a statement, redefining the primary goal of renewable resource management and formulating four general principles for its implementation.

The participants in the workshops also prepared a detailed interpretation of the new principles, with respect to marine resources now under consideration by the United Nations Conference on the Law of the Sea (Appendix 4). Lastly, they suggested that resource management institutions—international, national, state, and local—should incorporate the new principles in their charters, and further, that those institutions should be evaluated with respect to their capacities to implement and achieve the basic goal as defined.

The participants (Appendix 1) were invited on the basis of outstanding expertise and experience in research and management of wild terrestrial or aquatic living resources. They were drawn from a broad spectrum of disciplines and all had focussed on the theory or practice of conservation and exploitation of the resources involved.

The objective of the meetings and workshops was to produce a written report intended to present the "state of the art" as perceived by the participants. The procedure followed was to start with individual working papers, and carry them through successive reviews, revisions, and redrafts. The text is the final report of the workshops, assembled and edited by Sidney Holt and Lee Talbot. To assure that it accurately reflected the participants' views, the final draft was circulated to all participants for correction and approval.

INTRODUCTION

Man is making ever-increasing demands on the world's wild living resources—fishes, aquatic invertebrates, reptiles, marine and terrestrial mammals, and birds—for food, other animal products, and other values. The United Nations Conference on the Human Environment in 1972, the World Conferences on Food and on Population in 1974, and the fisheries aspects of current Law of the Sea negotiations, attest to the growing international recognition of the problems thereby created. At the same time, it is clear that past attempts to manage those resources, or the failure to manage their exploitation on a rational basis, have allowed gross depletion of many of them, rather than assuring sustained or improved yields and values.

The absence of rational management policy, or the application of a policy that results in overutilization or other abuse of a resource, results in the loss of the full range of benefits to both present and future generations. Effective management policy, on the other hand, can result in an equitable distribution of benefits between present and future users of the resource.

Considering the world as a whole, we can say that most exploitation of wild living resources has not been managed in the strict or scientific sense of the word. Where management has been attempted, the concept of maximum sustainable yield (MSY) or some related single species approach most often has been adopted as the basic concept (Appendix 3). A number of other factors have been involved in past failures to achieve rational management of wild living resources. In view of the significance of those resources to human welfare, it is timely to redefine the scientific principles that should underlie their conservation and management.

The term "conservation" has been used with such a variety of meanings, and often without definition, that it is tempting to avoid using it here. Yet it does have the specific meaning we need of "wise use," involving "keeping for future use," for which concept there is no better word in the English language. Therefore we have retained it (Appendix 2).

The maintenance of resource systems in desirable states is an essential part of scientific, ecologically sound management, and should be the *primary goal* of conservation policy. Such states can provide continuing social benefits and cultural values. Benefits and values may be tangible or intangible, realized or potential. A resource system in a desirable state would have the capacity to accommodate changing human values and to persist in the face of changing environmental conditions. Of particular importance is the need to avoid irreversible changes in the system as a result of human actions.

Effective management and successful conservation requires the existence of legal and institutional arrangements to implement scientifically based principles. While different resource users may have widely differing objectives, those objectives, and the corresponding legal and institutional arrangements to attain them are not the main concern of this report. However, the above *primary goal* is consistent with the aims of most national and international institutions concerned with the management of living resources. To achieve our primary goal requires a sophisticated approach to conservation that takes into account the ecosystem as well as the selected species or stocks considered to have special value at some particular time. Ecologically simplistic concepts such as maximum sustainable yield are not adequate for that purpose. More comprehensive concepts and procedures are suggested below.

THE CHALLENGE

The approaches to conservation measures, to secure future values, have varied from one situation to another. One approach is an *ad hoc* one—simply to try to find agreement on a collective action that enhances future values for all present participants. To achieve this, some inequities usually must be accepted; some users will have greater potential benefit than others and that can lead, and has sometimes led, to the failure of such an approach.

Another approach has been to define a specific goal of conservation. The most usual goal has been the maintenance of the resource in such condition that it is capable of supplying a maximum sustainable yield, and that has been the basis for regulating the exploitation of many wild species (Appendix 3). Strictly, maximum

FIG. 1. Pribilof fur seals (bulls, cows, and pups), St. Paul Islands, Alaska. Brought back from a seriously depleted population to the point where they have provided an annual harvest of tens of thousands of animals, the Pribilof fur seals were long regarded as the classic example of the success of single species management according to the concept of maximum sustainable yield. However, in recent years there has been a decrease in productivity of the population, and it is clear that there are factors involved other than direct harvest. Those factors probably include competition for food (pollock) from commercial fishing operations, deaths caused by seals becoming entangled in discarded fish nets and binding materials, physiological impact from pesticides and heavy metals, and possibly changes in social structure when the seals are ashore on the islands. (Credit: National Oceanic and Atmospheric Administration)

sustainable yield has applied only to some consumptive uses of the resource, but by referring to "values" instead of "yields," the concept could be generalized. The apparent simplicity of the maximum sustainable yield approach has appealed to legislators. It has been incorporated in many international instruments as well as in national and local legislation to regulate fish and game harvest. The concept has sometimes been advocated so forcefully as to imply that a maximum yield not only *could* be taken but *should* be taken; a policy of so-called "full utilization" leads to the view that a resource is in some ways being "wasted" if a maximum sustainable yield is not being taken. Such a view can be grossly misleading.

Where maximum sustainable yield has been applied, it has ensured recognition of the renewable nature of the resource as well as its vulnerability, and undoubtedly has sometimes served the purpose of restraining exploitation. Some failures in maximum sustainable yield management must be ascribed more to failures in application than to weakness in the concept. On the other hand, such a simplistic concept has a number of deficiencies and problems (Fig. 1). For example, it:

- focuses attention on the dynamics of particular species or stocks without explicit regard to the interactions between those species or stocks and other components of the ecosystem;
- concerns only the quantity and not the quality of potential yield or other value from the resource;
- depends on a degree of stability and resilience of the resource that may not exist;
- focuses attention on the output from resource use, without regard to the input of energy, of other natural resources, and of human skill and labor required to secure the output;
- may admit, and even encourage, overexploitation.

There are, of course, certain fundamental differences in conservation objectives when a resource is managed for commercial exploitation rather than for recreational use. Those differences are particularly evident when we compare the problems associated with managing some terrestrial vertebrate resources with those of marine fisheries. The maximum sustainable yield concept has not often been the explicit basis for the former. Small game management often is based on the annual production of a seasonal surplus being harvested down to a threshold density that will maintain what is believed to be a reproductive population in a steady state. Some avian species with high potentials for increase have been managed successfully on that basis in favorable localities with good habitat conditions. Allowable harvests of large ungulates (Fig. 2), on the other hand, are conceptually based more on the concept of limited carrying capacity of the environment, as presumably determined by the impact of the species on the vegetation in its habitat. In theory, surveys are made of vegetational conditions as an index of population pressure and the annual harvest is adjusted accordingly. In practice, other considerations often prevail. In the case of waterfowl (Fig. 3), harvest limits are set on the basis of surveys of aquatic conditions, breeding pairs, and indexes of production of young, with the objective of maintaining an adequate breeding population for the following year. Successful management of terrestrial vertebrates has often relied on habitat protection and restrictions on harvest methods.

In terrestrial situations, detailed observations of behavior, ecological relationships, and habitat response are often possible (Figs. 2, 4), whereas those factors usually are inferred indirectly from samples in aquatic situations. Terrestrial species provide greater opportunity than aquatic ones for rapid detection of response to management mistakes and to natural changes, and for control of harvest by species, sex, and age. Most of the harvested terrestrial species are herbivores so that the relationship between abundance of the species and its food supply not only can be observed directly, but is usually fairly simple and well understood. On the other hand, the bulk of the harvested aquatic species are carnivorous, so that the relationship between harvested species and food supply is not only much more difficult to observe, but is also likely to be quite complex.

Such differences do not mean that maximum sustainable yield is necessarily a more useful concept in the management of terristrial wildlife than in marine fisheries—it is not (Fig. 5). They do illustrate the particular difficulty in obtaining accurate data for the effective management of aquatic resources, and emphasize the need for more sophisticated procedures. Present procedures usually consider only the effects of exploiting an individual species or group of species in isolation, and fail to recognize any need for predicting the effects on other components of the ecosystem or reciprocal relationships between the species and its environment. Those effects may include changes (1) in the populations of competing or symbiotic species within the functional group of the exploited species,

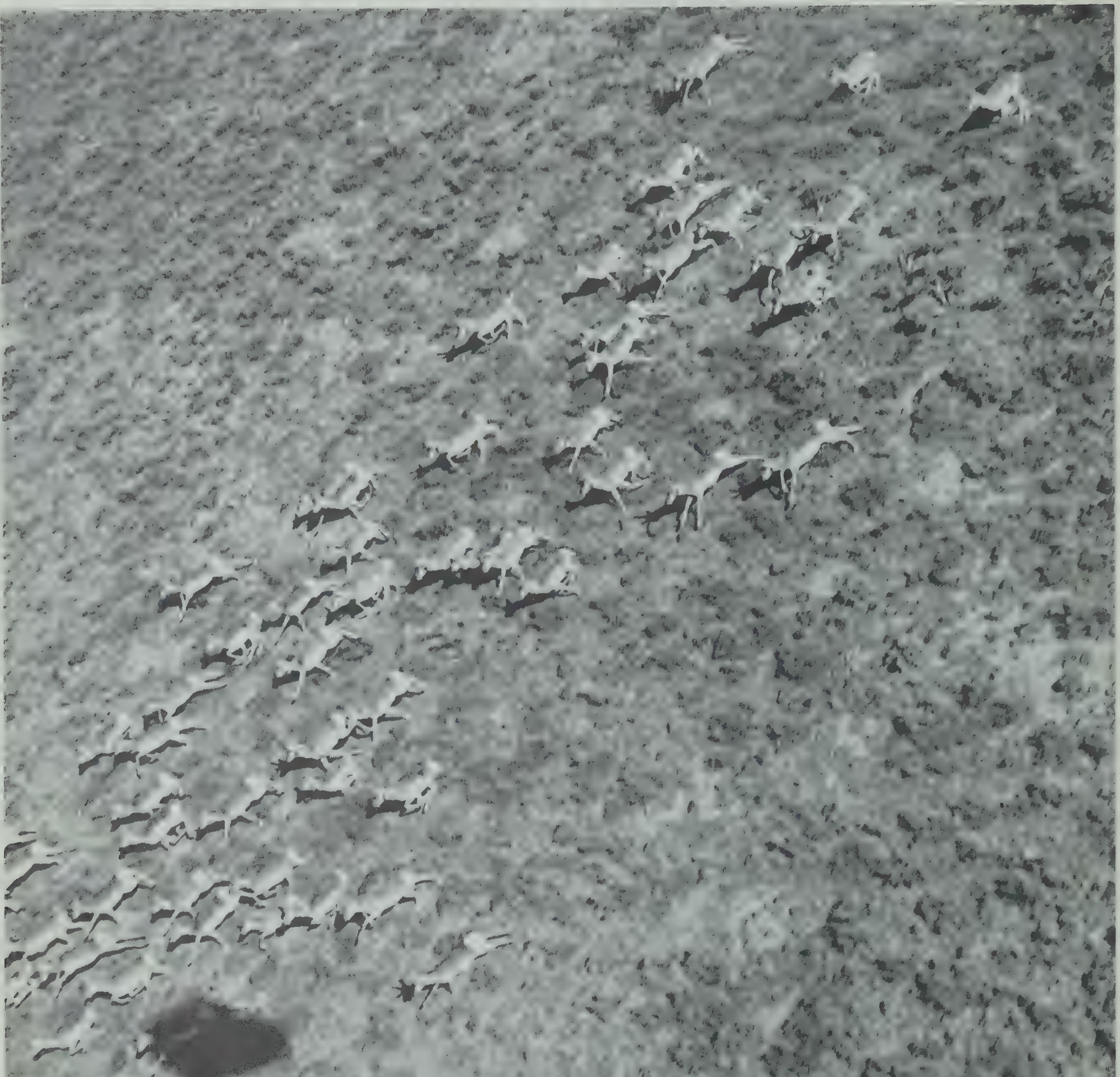

FIG. 2. Aerial survey of pronghorns, Sheldon Antelope Refuge, California. In management of such terrestrial species, direct observations of numbers, behavior, ecological relationships, and habitat condition are often possible, whereas those factors usually must be inferred from samples in aquatic situations. (Credit: U.S. Fish and Wildlife Service)

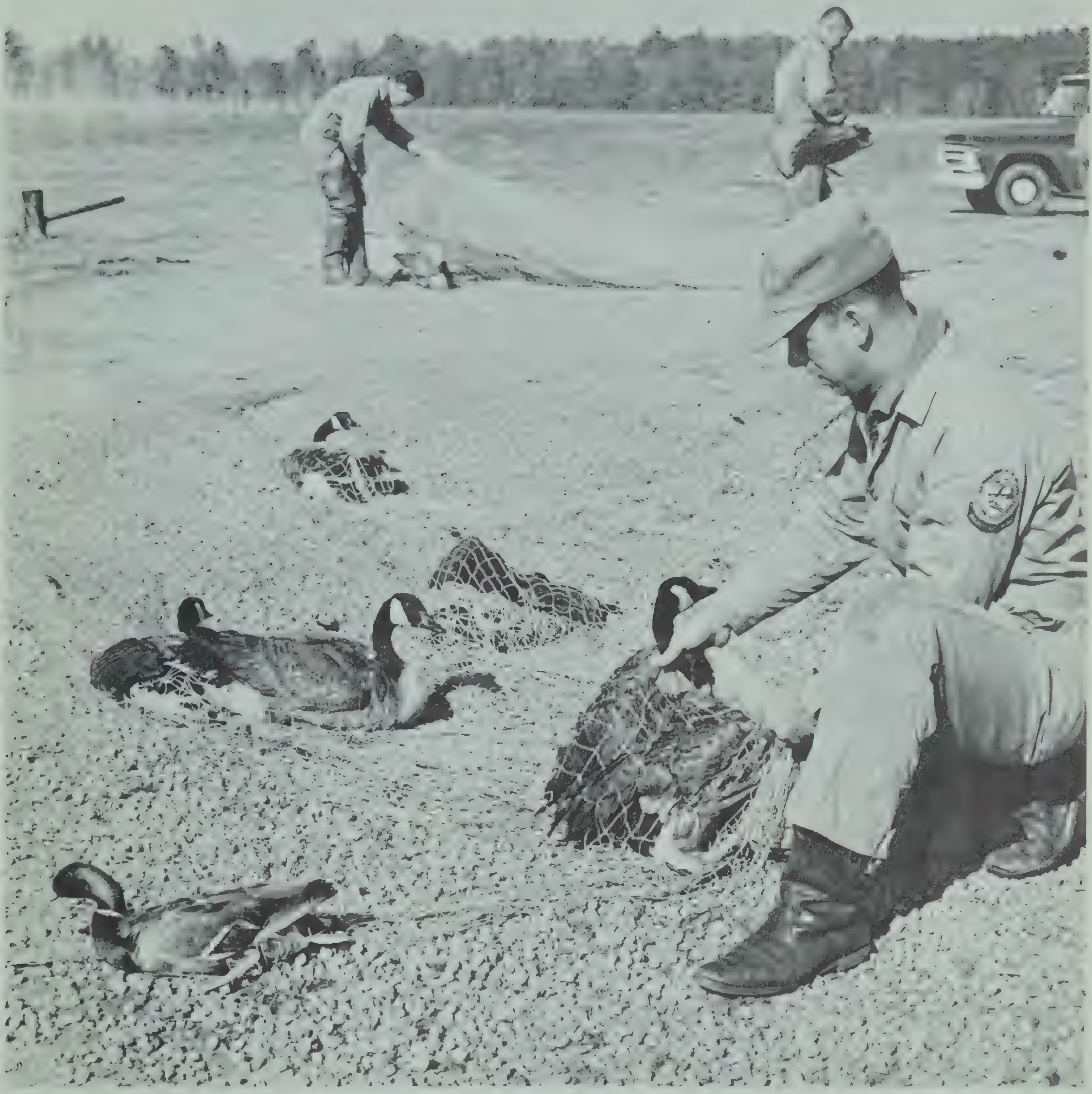

FIG. 3. Trapping and banding waterfowl (Canada geese and mallards) at the Blackwater National Wildlife Refuge, Maryland, in the course of studies on the population dynamics and migration routes. The resulting information is basic to management of this resource for both consumptive and nonconsumptive purposes. (Credit: U.S. Fish and Wildlife Service)

(2) in the vegetational structure and carnivore populations where the exploited species is a herbivore, and (3) in prey numbers where the exploited species is a carnivore. These are only first-order responses, and consequent changes in more remote parts of the system are probable.

No species exists in isolation. Exploitation of one species has some impact on other components of the ecosystem (Fig. 6), and valid principles for conservation would take due account of that fact. A truly ecological approach will, however, go further. Just as it is necessary, especially under conditions of intensifying use, to

FIG. 4. African elephants, Tanzania, Africa. The herd matriarch comes forward to protect her family, and often is the first shot. Elephant studies have shown the necessity of considering the social and behavioral factors in any management program. (Credit: Iaian and Oria Douglas-Hamilton, World Wildlife Fund)

view the species and stocks of immediate interest to man in the context of the ecosystems as a whole, so now those natural systems are seen in the context of their relationships with human institutions. Historically, many renewable resource stocks—especially marine animals—were exploited as common property resources, with little or no form of effective regulation (Fig. 7). Such exploitation often resulted in the depletion of stocks, not only economically but also biologically. Such depletion—or the threat of it—has led to the establishment of institutions that have attempted to control exploitation. In practice, such institutions occasionally have been successful in controlling biological depletion at least temporarily, but much less successful in reducing economic overexploitation. One factor cited is that under such conditions, resource rents may have remained at a low level, and the corresponding overcapacity of industry has often led to continuing difficulties even in controlling biological overexploitation.

A more sophisticated management approach might attempt explicitly to achieve economic efficiency in resource exploitation in the long run. One theory postulates that such regulation could generate economic rents that could in turn be utilized—reinvested—so as further to improve the effectiveness of management. Unfortunately, that approach has not been attempted at the international level, in part at least because of a continuing failure to recognize the magnitude of the potential benefits, and in part, because of the problems of distribution of benefits to new participants or nations in a fishery. The failure to apply effective management results in the loss of the values that could be realized from the resource.

FIG. 5. Shrimp fleet at Galveston, Texas. The principles for conservation of wild living resources apply as much to invertebrates as to vertebrates. (Credit: National Oceanic and Atmospheric Administration)

Newly defined principles of conservation need to be applied in such a way as to facilitate securing and sustaining such benefits.

THE PRINCIPLES OF CONSERVATION

The embodiment of simplistic formulations in legislation has reinforced a belief that hypotheses, such as that the size of a stock essentially determines the yield it can sustain in perpetuity, have in fact been validated, and that the desirable state of a resource system can be exactly specified in terms of a single criterion. That belief does not survive scrutiny, and attempts to apply simple criteria can hinder attempts to use renewable resources wisely. At the same time, man's uses of natural resources are continually intensifying and becoming more widespread, and as a result more demands are put on our ability to understand and predict the consequences of such uses. Although present and near-future needs for increased food supplies might partially and temporarily be met by increased exploitation, conservation for the long term must take precedence in defining new guiding principles to meet the criticisms described in the previous section.

The particular patterns of resource use will, of course, vary from place to place and time to time, but this means only that the new general principles would be applied in a different style, and with differ-

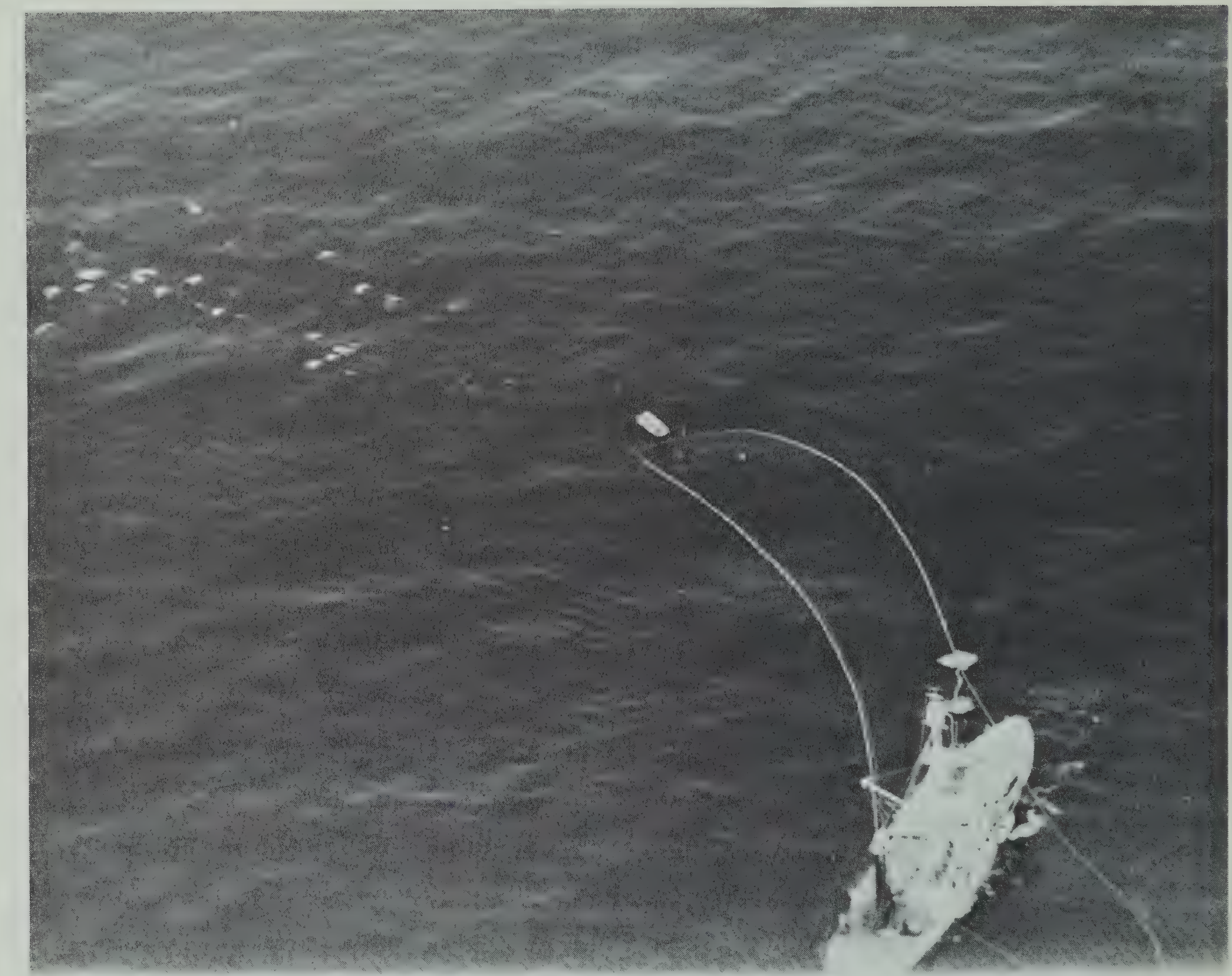

FIG. 6. Purse seiner in the eastern tropical Pacific Ocean fishing "on porpoise" for yellowfin tuna. The net is deployed around a school of porpoise because the tuna are often found in association with them. Unless care is taken when the seine net is pursed, the porpoises may be drowned. Such "incidental take" has represented a gross waste of living resources, ranging from around a quarter of a million to well over a half million dolphins per year. Regulations under the Marine Mammal Protection Act of 1972, enforced for the first time in 1977, reduced that loss to about 24,000 animals. In the photograph, porpoises may be seen escaping from the seine, assisted by fishermen in the skiff. (Credit: Naval Undersea Center)

ing emphasis, from one situation to another. Since there is a growing appreciation of the fact that effective conservation, even of a particular species, must take into account interactions between that species and its living and nonliving environment, the formulation of principles here includes the ecosystem within which the species exists.

The consequences of resource utilization and the implementation of principles of resource conservation are the responsibility of the parties having jurisdiction over the resource or, in the absence of clear jurisdiction, with those having jurisdiction over the users of the resource. The privilege of utilizing a resource carries with it the obligation to adhere to the following four general principles:

1. The ecosystem should be maintained in a desirable state such that
   a. consumptive and nonconsumptive values could be maximized on a continuing basis,
   b. present and future options are ensured, and
   c. risk of irreversible change or long-term adverse effects as a result of use is minimized.

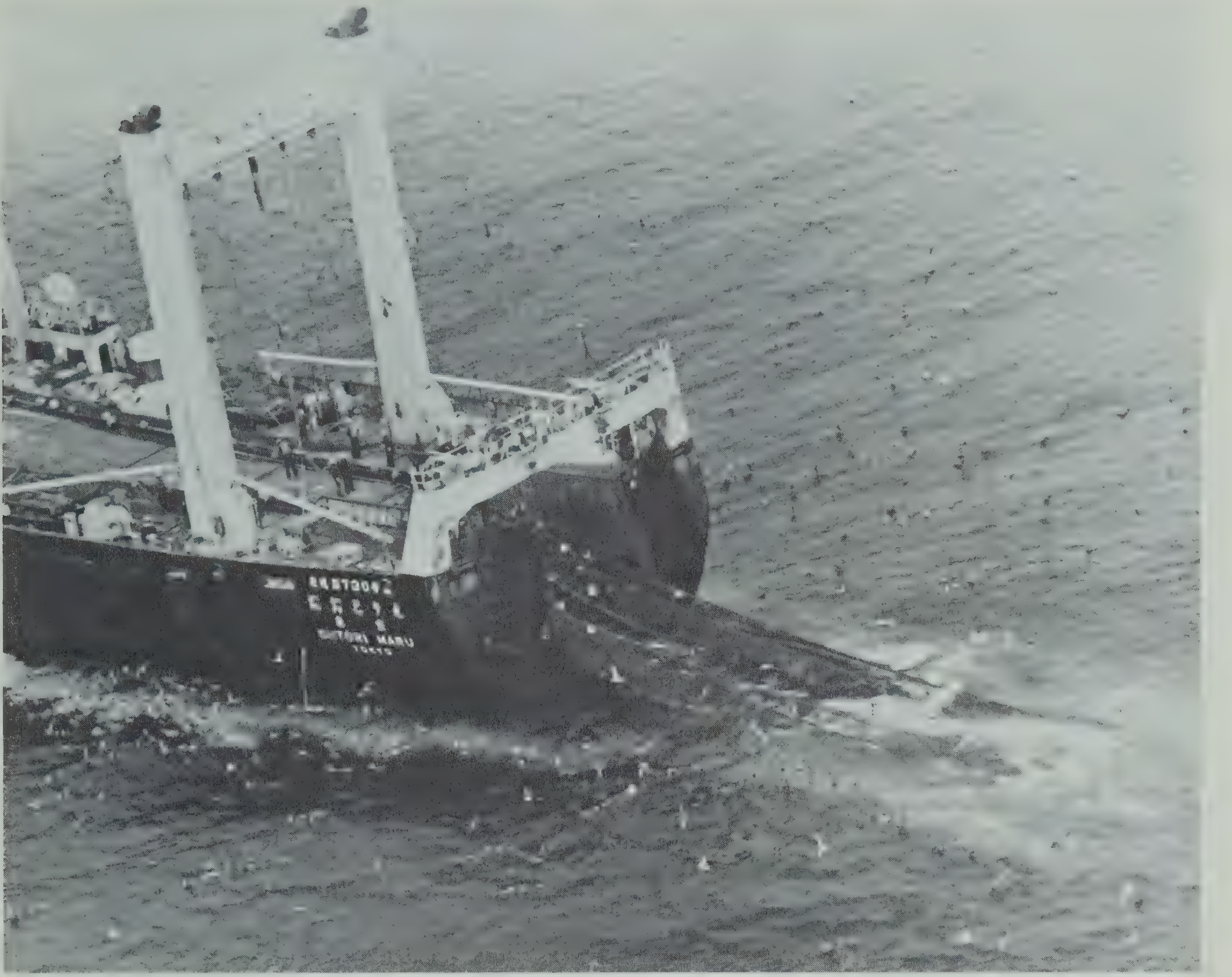

FIG. 7. Japanese trawler, Bering Sea, bringing in the catch. Starting in the mid-1950s, the Japanese, and subsequently Soviet, distant water fleets rapidly increased their harvest of ground fish, reaching annual levels of more than two million metric tons from 1971 through 1974. The impacts of that technology extend far beyond the target species. For example, the trawlers catch accidentally, then usually discard, immature halibut, most of which die. Annually, the weight of that incidental, wasted "harvest" is significantly greater than that of the adult halibut in the intentional halibut fishery. The trawlers' incidental take contributed to the crash of the halibut fishery in the 1960s, and has precluded its recovery since then. The trawlers may also compete with the Pribilof fur seals for pollock, reducing the potential seal harvest. (Credit: National Oceanic and Atmospheric Administration)

2. Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect.
3. Measures to conserve a wild living resource should be formulated and applied so as to avoid wasteful use of other resources.
4. Survey or monitoring, analysis, and assessment should precede planned use and accompany actual use of wild living resources. The results should be made available promptly for critical public review.

Principle 1 recognizes the necessity of maintaining each of the world's ecosystems in a desirable state in which potential users of resources within a system may realize a diversity of values in perpetuity. The three criteria of Principle 1, taken together, cover the main features of the desirable size and structure of the living resource, its natural change in time, and its relation with the varying physical environment. Criterion 1a is a more ecologically valid development from the maximum sustainable yield concept since it specifies a wider range of benefits to be maximized rather than simply specifying a particular maximum yield as a primary goal. Options should be kept open (Criterion 1b) since values are diverse and can be expected to change. Further, advances in scientific knowledge and the ensuing technology will provide new uses and new perceptions that may well call for different treatments of living resources. Our understanding of diversity, organization, and dynamics of ecosystems, as well as of the genetic basis and evolutionary development of various forms of life, can be expected to improve. We must thus strive to maintain any given ecosystem in a state that permits changing values to be appreciated and new knowledge to be applied.

Adjustments to changing values and needs, and correction for the results of previous actions, may also require the capacity to reverse the outcomes of previous actions (Criterion 1c). Thus, it is desirable to avoid those actions that alter ecosystems in such a way that the return of the system to its previous state is impossible or unlikely. The extinction of a species and destruction of habitat are examples of irreversible outcomes. Often, the outcomes of proposed actions cannot be adequately predicted, and in such cases the apparent relative potential of actions to lead to undesirable effects may serve as a basis for their selection or rejection. Actions that are spatially or temporally limited are less likely to lead to large-scale irreversible outcomes than similar actions that are widespread or persistent.

The several criteria for a desirable state may not always appear to be wholly compatible, and defining the desirable state will then involve compromises. In applying Principle 1, fulfillment of its Criteria 1b and 1c may, strictly, involve acceptance of somewhat less than the maximum of a particular single yield that could possibly be realized on a continuing basis as provided in Criterion 1a. Such "sacrifice" will, however, be relatively small and will be compensated for in other ways. Specifically, it will contribute to safety (Principle 2) and to the avoidance of waste of other resources (Principle 3). It may also increase the net benefits to each user in realizing consumptive values. Further, it should be recognized that Criterion 1a refers to *values*, not simply to *yields*. Value, in this context, implies more than economic yield.

Ideally, resource conservation measures should be based on a thorough understanding of the biological characteristics of the resource and its environment. Principle 2 recognizes that both our knowledge and our arrangements for applying that knowledge will always have shortcomings, and .that they should be allowed for so present management does not inadvertently prejudice future values.

In practice, our knowledge is often seriously inadequate, and predictions are uncertain. Uncertainty may arise from ignorance of such things as biological growth rates, interactions with other species, effects of the species on its habitat, and unpredictable environmental events. Similarly, the imperfection of institutional arrangements can lead to errors and delays in the implementation of policy decisions. To reduce the risk of irreversible changes or other long-term adverse effects, an appropriate safety factor should be included in all conservation measures. The magnitude of the safety factor should be proportional to the magnitude of the risk. The greater our ignorance of the resource—particularly of its capacity to respond to changed conditions—and/or the weaker the management institutions, the greater the safety factor must be.

Any use of a living resource must involve use of other resources, such as capital and energy. It is well known that the conduct of many fisheries, including some supposedly managed on the maximum sustainable yield principle, has involved an overcommitment of resources such as capital, labor, and fuel (Fig. 8). Specific measures for conserving a particular resource should be chosen and applied in such a way that they do not encourage undesired and unnecessary waste

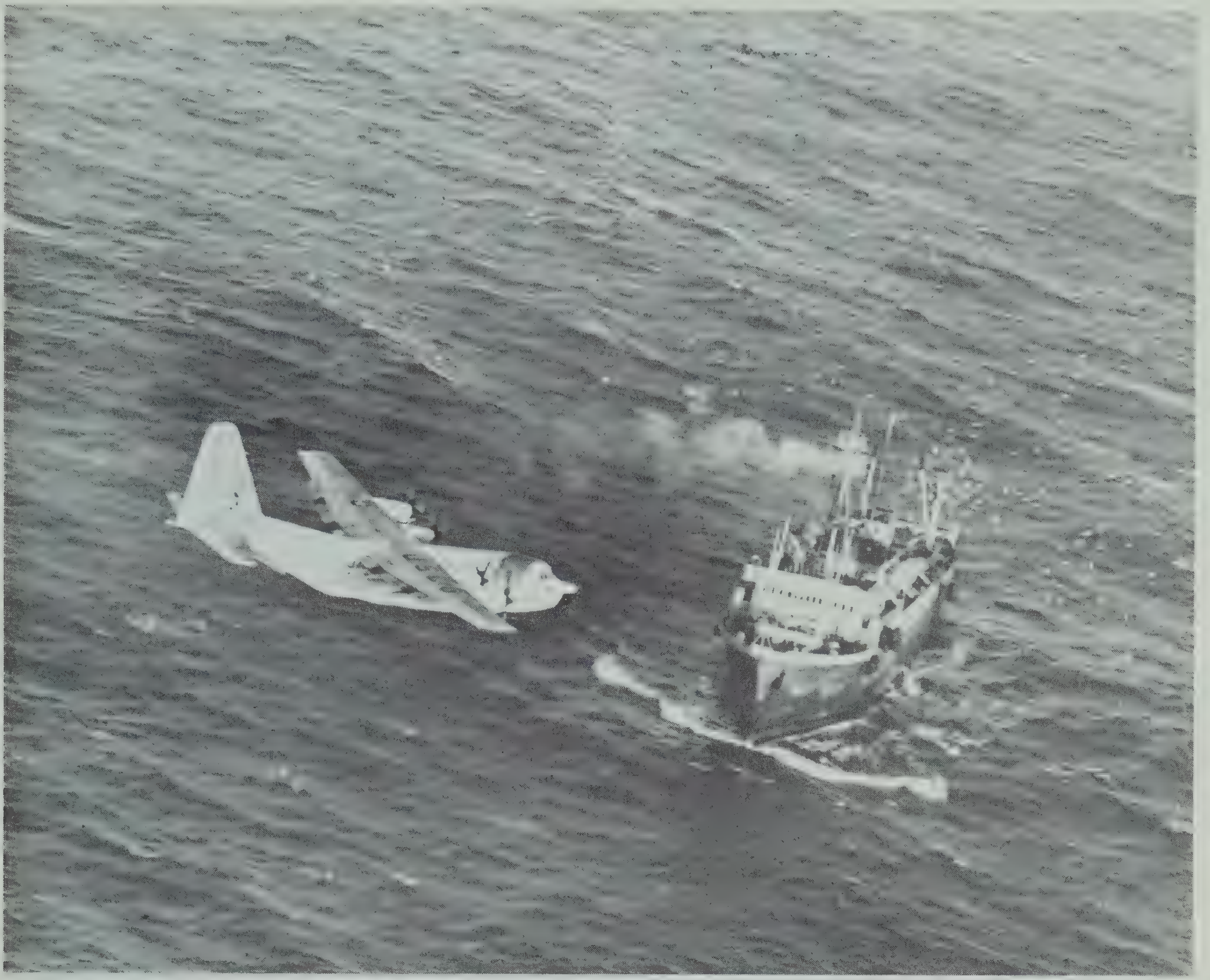

FIG. 8. Soviet stern trawler under surveillance by U.S. Coast Guard aircraft. Sophisticated and efficient distant water fisheries of such nations as Japan and the Soviet Union are a major factor in harvest of living resources from the world's oceans. (Credit: National Oceanic and Atmospheric Administration)

or misuse of other natural resources. The conservation of other resources will nearly always require utilization at a level appreciably less than the supposed maximum sustainable yield. The safety factor will thus often result in a net economic gain in both the short and long term. This should not be taken to imply that consideration should not be given to noneconomic values. Where recreational or nonconsumptive values are of primary concern, consideration of economic efficiency may be inapplicable. A further waste to be avoided or minimized may occur through incidental destruction of "nontarget species," i.e., species other than those primarily valued and sought, such as porpoises in the yellowfin tuna fishery (Fig. 6).

Principle 4 concerns the needs and duties of information gathering, interpreting and explaining, that are an essential part of resource management. Timely and accurate scientific information is an essential component of a conservation program (Fig. 9). The amount of investment in such assessment should be related to the intensity of use, the complexity of the problem, and the vulnerability of the system to adverse impact.

Data collection—in principle by all those who exercise or claim a right to use a resource—is itself extremely important, but of equal importance is continual improvement in our understanding of processes in ecosystems and of methods to measure and predict the directions and rates of those processes. Such improved

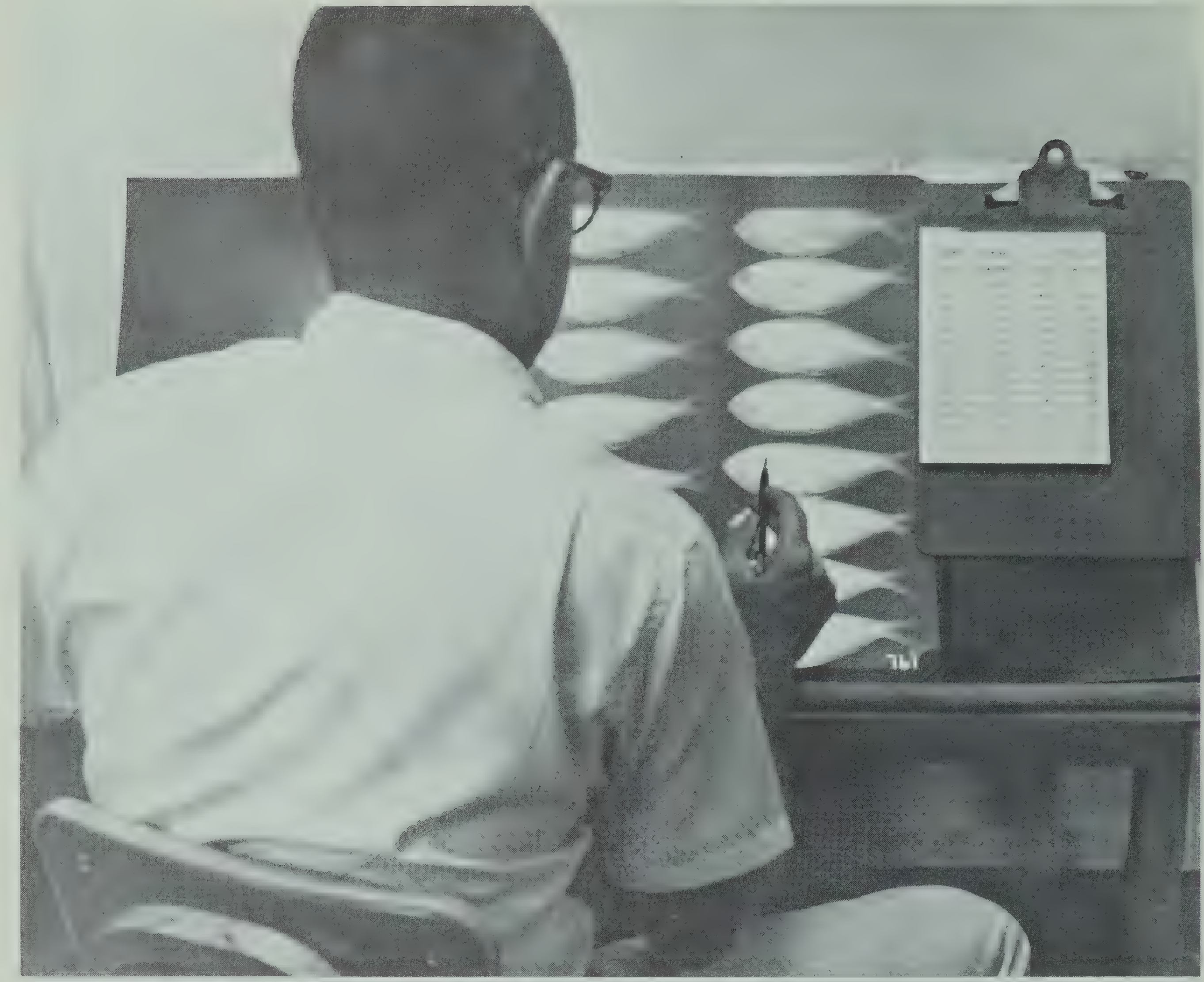

FIG. 9. Government scientists using radiograph for counting vertebrae and fin rays in population studies of menhaden. Improvement of the scientific information base, and the development of new technologies and methodologies is essential to effective management of living resources (Credit: National Oceanic and Atmospheric Administration)

information is necessary to improve and correct management approaches and to adjust them to changing conditions. Critical public review is necessary both to provide for accountability for data and decisions, and to ensure the opportunity for normal scientific peer review. Thus, Principle 4 implies both strengthening and some reorientation of research and research procedures.

APPLICATIONS

Obviously, it will not be easy to develop the techniques needed to put the four proposed principles into effect. It will take much time and considerable effort. If, as is hoped, the principles are widely accepted, high priority should be given to working out interpretations of them for particular cases, and suitable procedures for their implementation.

Clearly, the complexity of the problems involved is now being more widely appreciated. This is attested by the attempts to understand ecosystems as functioning units, as in the Biome Projects of the International Biological Program. In the management of aquatic and terrestrial resources, several institutions already have acknowledged the need to move beyond management based on the maximum sustainable yield concept toward broader goals. Some have considered certain aspects of the general principles outlined in this document.

The need to limit the rate of development of fisheries on newly exploited species in order to permit adequate assessment of the effects of fishing has been recognized and applied by the International Commission for the Northwest Atlantic Fisheries (ICNAF). Also, the concept of including interspecific effects has been incorporated by setting limits on the total harvest of all species from an area. The protocol of the International Commission for the Northwest Atlantic Fisheries stipulates that regulations may be proposed on the basis of scientific, economic, and technical considerations.

Available reports about the anchoveta fishery in Peru now reflect consideration not only of conventional and improved stock production models, but also determinations of the optimal number of fishing boats, the best capacity for processing plants, discussion of social effects of modifying the labor costs, and the phasing of some of the overcapacity into new fishing endeavors.

Some experimental management studies of warmwater recreational fisheries in the United States have recognized the importance of maintaining satisfactory age and size structures of fish populations in order to sustain fishing quality. Conservation and sustained benefits can be accomplished by programs that maintain the satisfactory qualities of ecosystems—both habitat and community structure.

In the International Whaling Commission (IWC), most of the principles are beginning to play a role in the establishment of harvest quotas. At its 1974 meeting, the Commission agreed that management of whale stocks should eventually be based on some "optimum" rather than simple numerical maximum sustainable yield, the Scientific Advisory Committee of the International Whaling Commission having recommended that "Scientific advice for management of whale stocks should be based not only on the concept of sustainable yield and numbers, but should also include considerations such as total whale weight rather than numbers, interactions within the marine ecosystem, and the health of the ecosystem as this concept is quantified." The "New Management Procedures" now in effect, provide for a safety factor, and the scientific analysis and assessments have been much improved, with publication required.

In the management of fur seals in South Africa, attention is now being given to the balance between the fur seal and the pilchard populations on which they prey, both species being of economic value in their own right.

There are examples of harvesting of wild ungluate populations in African nations where management policies emphasize balanced harvesting of several species simultaneously in the context of the condition of the environment.

The Marine Mammal Protection Act of 1972 is the first national legislation to place maintenance of the health of the ecosystem as the primary objective of management. Its declaration of policy states that:

> "Species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functional element of the ecosystem of which they are a part . . . . The primary objective of their management should be to maintain the health and stability of the marine ecosystem. Wherever consistent with the primary objective, it should be the goal to obtain an optimum sustainable population, keeping in mind the optimum carrying capacity of the habitat."

These examples serve to demonstrate how the need for new approaches has already brought some institutions to adopt certain aspects of the principles defined here. The following steps are now needed:

(1) The charters of resource management institutions should be amended as necessary to embody the four general principles, and

(2) The institutions should be evaluat-

ed with respect to their capacities to implement the principles.

APPENDIX 1

List of participants

P - Attended planning meetings
1 - Attended first Workshop
2 - Attended second Workshop

(All attendances at Workshops were in personal capacity.)

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APPENDIX 2

Conservation

The term "conservation" has been used with the meaning of "wise use" involving among other things, "keeping for future use." In its broad definition, it includes management measures, and means the collection and application of biological information for the purposes of increasing and maintaining the number of animals within species and populations at some optimum level with respect to their habitat. Used in this way, conservation refers to the entire scope of activities that constitute a modern scientific resource program, including but not limited to research, census, law enforcement, and habitat acquisition and improvement, and periodic or total protection as well as regulated taking.

Conservation may refer to a set of measures intended to maintain a resource in a desirable state, or to designate the process of attaining such a state. In a narrow context, conservation can refer to the application of measures that in some way restrain the otherwise free use of a resource in order to ensure that it retains certain desirable natural properties. Used in this way, conservation can be considered as one facet of rational resource management, which may also cover activities intended to improve the resource or ameliorate damage resulting from previous misuse of it. (Of course, in its broader context, conservation includes all those activities.)

The need for conservation arises from a combination of two conditions:

(1) that the use of the resource is sufficiently intensive to significantly affect it, and
(2) that the pressure of present use is such that unless restrained or otherwise regulated it will prejudice future uses and values.

The development of technology and the increase of human populations now ensure that practically all wild living resources are accessible to, and vulnerable to change—sometimes drastic change—by human agency. The second condition might, in theory, apply to an individual man, owning and subsisting on a wild resource who decides to limit his hunting now so that he has food for next year and the year after. Noncompetitive groups may also impose restraints on themselves in the expectation of providing better for the future of their members and their kin. In practice, however, in the modern world, the need for conservation measures arises essentially because any group of users usually will give relatively greater weight to present values with respect to future values, than does the larger group of which the user group is a part. Conservation measures are the means to correct such an imbalance by adding more weight to future values than would be accorded to them by the separate users of the resource.

Each resource user's relatively short-term view is enhanced by his uncertainty of future benefit. This arises from the expected behavior of contemporary competitors and insecurity of his future access to the resource. Societies, therefore, often seek to establish a longer-term view by eliminating or reducing the risks of exclusion and detrimental competition. Thus, indefinite or long-term rights of use may be granted, competition regulated through allocations, and conflicts in different kinds of use of the same resource resolved by applying some formula. Such actions are not considered to be included among the conservation measures to which attention is here directed, but they are complementary to them. Experience has shown the need for both types of social action at all levels—from the control of individual users by local authorities to the self-regulation of national activities through international mechanisms.

APPENDIX 3

The Concept of Maximum Sustainable Yield

The maximum sustainable yield (MSY) is the greatest harvest that can be taken from a self-regenerating stock of animals year after year while still maintaining a constant average size of the stock. It is derived from the hypothesis—supported to a certain extent by observations—that a population of animals, in growing from an initial small number, at first increases more or less geometrically (exponentially) but that the rate of increase slows down as the population gets larger. The graph of population size against time is thus an S-shaped curve that eventually approaches or reaches a "final" size, that reflects the *carrying capacity* of the habitat of the population (Fig. 10). At that level, the death rate is balanced by recruitment, and a "steady state" is attained. The simple theory then postulates that the final size is actually the *initial* size of the renewable resource before man begins exploitation, and that when he begins to take an annual harvest the stock is reduced. According to the theory, the potential of the stock for increase is assumed to be determined by its size, and it presumably can be held steady at a certain size by removing each year a catch equal to that potential rate of increase; this is a "sustainable yield." So if the population growth curve is S-shaped, the greatest yield can be sustained from a stock of intermediate size, corresponding with the turning point (inflection) of the population growth curve. Study of such curves suggests that the intermediate stock level to be expected in many cases would be between about 40 and 60 percent of the level at "carrying capacity," although for some species the level may be higher.

The simple conceptual model outlined above, and also some more complex mathematical models, exhibit the property of a single maximum yield as a function of stock size. According to certain commonly used theoretical models of population growth, maximum sustainable yield should be obtainable from a stock level about half the level at "carrying capacity" (Fig. 11). Such models involve a number of assumptions, the most important of which may be summarized as follows:

- — the stock is more or less self-contained;
- — the stock has attained, before exploitation began, a steady state, at the carrying capacity;
- — there are no significant trends in carrying capacity during the period of exploitation;
- — the nature of the implied density de-

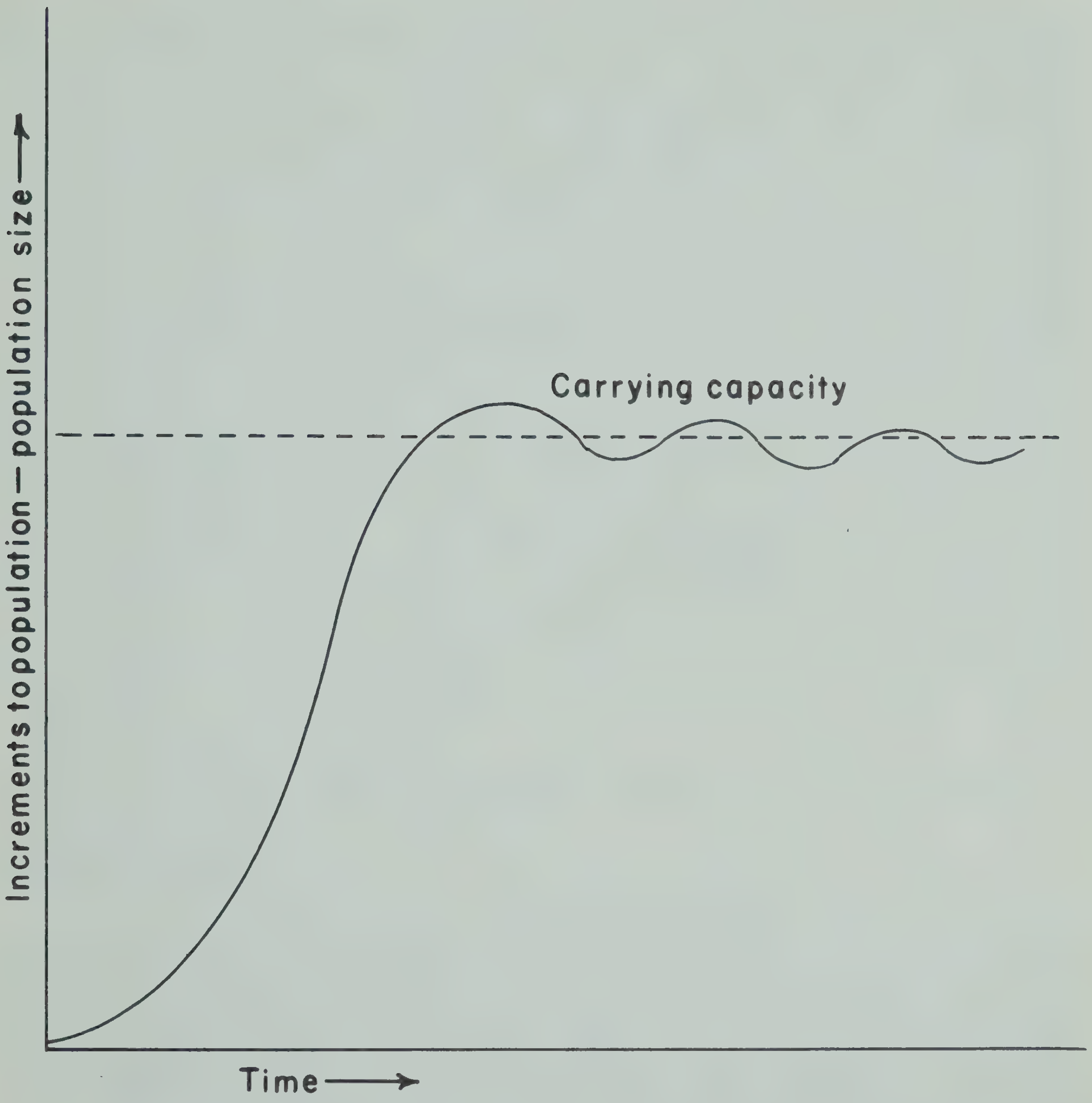

FIG. 10. The population curve is S-shaped because increments to the population are slow when the population is at a low level, with few individuals reproducing; the increments increase steeply when the population is higher and all individuals are reproducing at maximum rate; and the increments level off when the carrying capacity of the environment is reached, and mortality or other loss balances recruitment.

pendence of reproduction, growth and/or natural mortality, and in particular, any time lags in the response of the stock to exploitation, are not such as to cause fluctuations of large amplitude in the stock; and

- the process of reducing the "initial" stock by exploitation is reversible.

It is in practice usually very difficult to test any of those assumptions. Stocks have occasionally been reduced to less than half their initial size, and then recovered under full or partial protection (as in the case of the North Pacific halibut). In other cases, severely reduced stocks have never recovered, in spite of receiving total protection (such as the

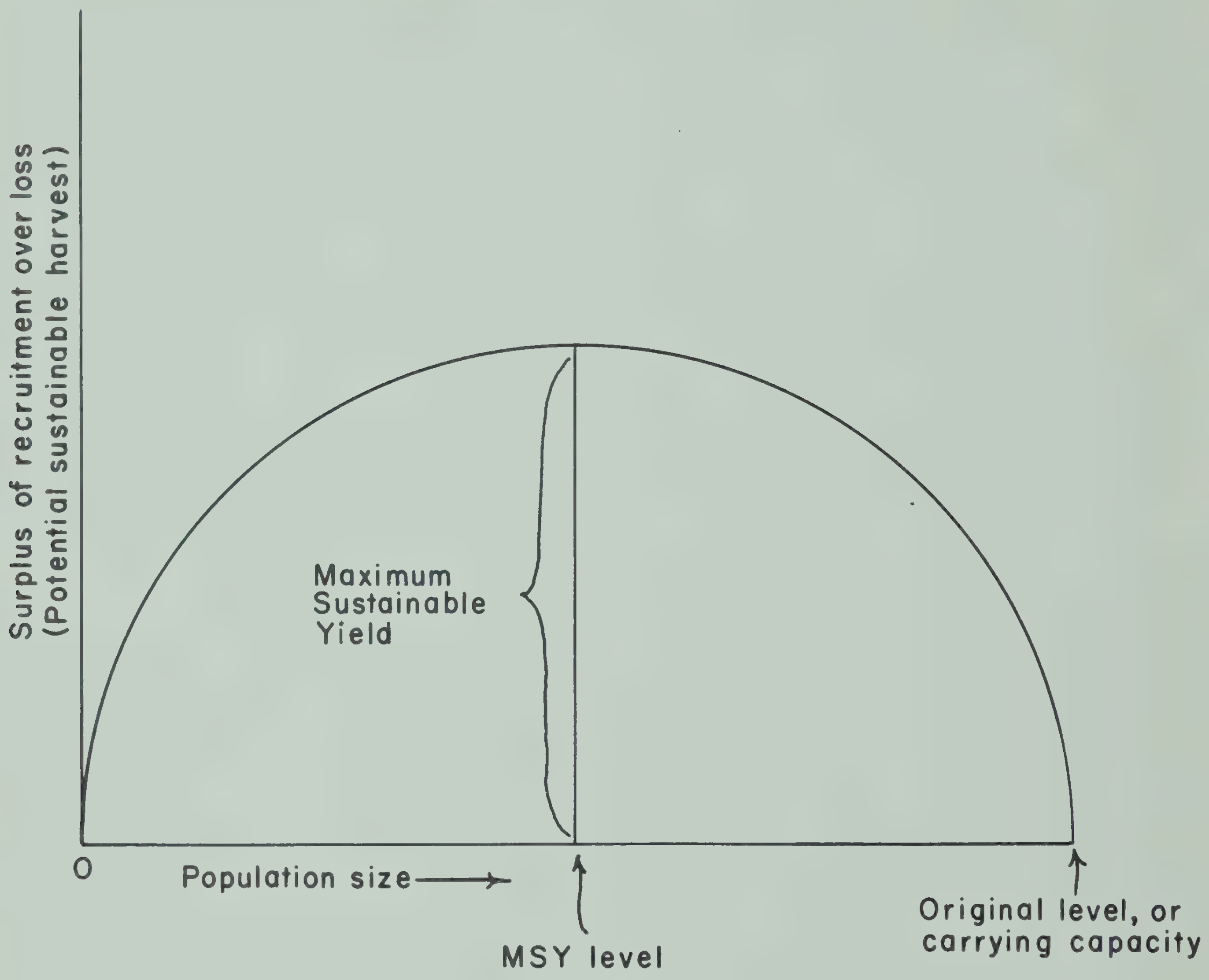

FIG. 11. The maximum sustainable yield concept is based on the assumption that an unexploited population exists at an equilibrium density, maintained by density dependent factors—i.e., it is at the carrying capacity. When the population is reduced and the density lowered, recruitment rates increase and exceed rates of loss. The difference between the recruitment and loss represents the number of animals that can be removed through exploitation, without reducing the population further, and if that number is removed annually, it is assumed that the population will be stabilized at the new, artificially induced equilibrium density. Under a strict abstract logistic curve condition, the population density producing the greatest harvestable surplus—the maximum sustainable yield—is one-half the "original level."

blue whale). In some cases, reduction of one species has led to the increase of another, unexploited species, and a change in the composition of the ecosystem (such as in the case of the California sardine and anchovy). We have as yet no sure means of predicting such consequences. Although a number of methods have been devised and used to estimate the parameters of the models described, they all depend on assumptions that are both overly simplistic and unproven. For example, the effect of exploitation on the age composition of a population has often been ignored, or it has been assumed that a reduction of the proportion of old individuals will result in an increase in reproduction. Under exploitation, the age composition usually is truncated, with the younger age groups comprising a higher proportion of the total. This occurs where exploitation is nonselective as well as where there is selection for larger—usually older—individuals. If, in a given species, the older age groups have higher reproductive rates—and particularly if the youngest several age groups constitute a prereproductive stage in the life history—an exploited population with truncated age structure will have a lower relative reproductive rate than would a population in which all individuals had an equivalent reproductive potential.

The social organization of the wild population is another factor to which far too little attention has been given in development of the concept of maximum sustainable yield. Dominance patterns, involving the supremacy of one or a few males that accomplish all or most of the breeding, exist in many species. Those patterns may rather delicately control the reproduction of a population, and if the patterns are destroyed, that control can be upset, in some cases, reducing the reproductive rate. Another aspect of concern is the effect that loss of group leaders experienced in foraging or migration, may have on group survival (Fig. 4).

From an ecological point of view, the major problems associated with maximum sustainable yield involve its concentration on the stock involved to the exclusion of factors such as:

- relationships within a trophic level (e.g., competition);
- relationships between trophic levels;
- impacts on symbiotic or commensal relationships; and
- changes in carrying capacity due to factors such as climate, pollution, and other human influences.

In sum, the concept of maximum sustainable yield as a simple function of stock size was developed to provide a generalized approximate description of the response of a stock or species to exploitation. It has served a useful evolutionary function, as a means of generalized description, and as an elementary teaching aid for students and for administrators. It has provided a preliminary conservation goal where it has been used to try to avoid or correct overexploitation. It has played a significant role in the evolution of understanding of wild populations. However, like some other simplified concepts, maximum sustainable yield has become institutionalized in a more absolute and precise role than intended by the biologists who were responsible for its original formulation. It is being expected to perform functions for which it was never intended, serving for example, as the sole conceptual basis for or goal of management in some cases. Once a concept has been adopted and institutionalized, it is difficult to change it. In this case, because of its institutionalization, the concept of maximum sustainable yield is now an obstacle to the acceptance of concepts that derive from present ecological knowledge, and that would provide a more adequate basis for management. A more adequate basis is especially necessary at this time when the overall impact of man on the biosphere is increasing and diversifying as never before.

APPENDIX 4

Application to the Law of the Sea

Summary

The Workshop prepared a statement of principles for the conservation of wild living resources that could meet modern needs. The statement redefines the primary goal of renewable resource management and the conditions for effective application of the principles. In this Appendix to the report of the workshops the statement is adapted to specific problems concerning the living resources of the sea, particularly, but not exclusively, those that are or may be internationally managed. The document explains the reasoning behind this endeavor, and annexed to it is a form of words that it is suggested might usefully be included in the text of instruments now being prepared by the United Nations Conference on the Law of the Sea.

Text

Man is making ever-increasing demands on renewable natural resources, for food and for other products and values. The United Nations Conference on the Human Environment in 1972, the United Nations Conferences on Population and Food in 1974, and the current United Nations Conference on the Law of the Sea (UNCLOS) all attest to rising international awareness of the global problems created thereby. With respect to the wild living resources, including fishes and other marine organisms, it is evident that although much progress has been made in the past three decades, some attempts to manage those resources have nevertheless permitted gross depletion of several of them, rather than assuring continuing, high and improved yields. Absence of an effective policy for rational management, or the application of a policy that results in overutilization or other abuse of a resource, results in the loss of potential benefits to both present and future generations. Losses with respect to marine resources have been estimated roughly in the order of several hundreds of millions of dollars annually. Such losses will increase unless appropriate policies are implemented soon. An effective policy would, on the other hand, secure great benefits and ensure that they are distributed equitably both among nations and existing users, and between present and future generations.

The United Nations Conference on the Law of the Sea has concentrated on the equitable distribution of fisheries resources among states, and hence of potential benefits from their use, rather than on the problem of balancing present and future uses. Proposals submitted to the Conference to date address more the question of rights, access, and jurisdictional limits than the formulation of overall long-term objectives. This is understandable, in view of the urgent need to resolve existing and potential conflicts among nations and among different users of the ocean. The two questions are, however, linked. The task of the Workshops was limited to close examination of the latter and to suggest new approaches to its solution. It is hoped that the suggestions made will be useful to those persons engaged in preparing new legislation covering those matters.

Management failures are attributable at least as much to institutional weaknesses as to shortcomings in the formulation of objectives. Those aspects are, however, also linked; in particular, attempts to apply unsound objectives lead to the sharpening of conflicts and to stress and failure in management institutions, and hence to less than optimal use of resources.

If management as a whole is concerned primarily with the allocation of values among interested parties who use or may use a resource, conservation is that component of management which regulates the relationship between current and potential values (Appendixes 1 and 2). The primary goal of conservation policy is the maintenance of resource systems in desirable states. Such a goal is consistent with the perceived evolutionary direction of international institutions.

The Workshops agreed on a set of Principles for the conservation of wild living resources. Those Principles provide guidelines for achieving the primary goal; they represent, inter alia, an attempt to specify what are desirable states in this context. In addition, a number of criteria were agreed that should be met in applying the Principles. For this, a sophisticated approach to management is necessary, taking into account the basic characteristics of ecosystems as well as the properties of selected species and resource stocks that may be of interest to certain users at particular times. Simplistic goals of conservation, including the widely adopted one of assuring "maximum sustainable yield," prove to be inadequate.

The desirable state of a resource system is defined as one that fulfills the following three conditions:

(1) physical yields, or other derived values, could be maximized on a continuing basis;

(2) diversity of present and future options in using it are ensured; and

(3) risk of irreversible change or of long-term adverse effects resulting from use is minimized.

These three conditions do not contradict each other, but they are not always wholly compatible. Where the desired state is some compromise between them, Conditions 2 and 3 may be fulfilled by foregoing some of the continuing yield the potential for which Condition 1 seeks to maximize. Such sacrifice will, however, be relatively small, and compensated for by other benefits to present and future users.

The set of Principles prepared by the Workshop are generally applicable to terrestrial, marine, and freshwater situations. With respect specifically to the marine environment, it is suggested that the instruments to be prepared by the United Nations Conference on the Law of the Sea should refer explicitly to those Principles and to the necessary conditions for their application in various circumstances. This might best be done by including an appropriate definition of "conservation" and specification of the main conditions. Accordingly, an annotated draft text is offered in the Annex to this Appendix. It includes valid ideas expressed in existing texts but reflects the better understanding of the nature of marine resources we now possess, as well as being responsive to modern fishing conditions.

The draft is divided into three paragraphs. These could, if necessary, be used separately, in articles, in a preamble, or in a Conference resolution, depending on the eventual form of the instruments now being prepared. They might serve to specify the general criteria for international management of fisheries in waters beyond national jurisdictions, and as guidelines to coastal states in exercising their authority in waters falling within their jurisdictions. Similar wording might be used to define the conditions for exercise of authority entrusted to any state, group of states, or international machinery.

"Conservation" is defined in Paragraph A of the Annex. The introductory words, and Subparagraph 1, are identical in form with, and similar in content to, Article 2 of the 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas. Similar wording has been included in a number of draft articles submitted by states to the United Nations Conference on the Law of the Sea, several of which acknowledge the need for more effective conservation programs and would impose a conservation obligation on coastal states as well as on international organizations established to manage fishery resources. Two small, but nevertheless significant, additions have been made here. Firstly, the definition refers both to the resources themselves and to their environment, which together constitute the marine ecosystem. Secondly, Subparagraph 1 indicates the need for supplies of food to be stable as well as maximal; the population levels of many stocks of fish and other marine animals are naturally variable, but under intensive use that variability can be increased, to the detriment of the fishing industry and, in some cases, endangering the survival of the stock. The intention of Subparagraph 1 is to ensure that stocks will generally be maintained at levels not lower, and possibly substantially higher, than the levels required to meet the definition in the 1958 convention, insofar as such levels can be determined.

Subparagraphs 2 and 3 introduce new principles. These are called for by changes in the nature of fisheries that have occurred in the 20 years since a United Nations Technical Conference prepared the earlier definition. Marine fisheries have, in that time, expanded greatly. They have diversified, and many more nations are participating in them. Although the world catch has continued to increase, the rate of increase has slowed—despite continuing increase in fishing effort—and occasionally in recent years the total annual catch has declined. Some of the resources on which large and valuable fisheries were based have proved unable to withstand the intensity of fishing to which they have been subjected, resulting in considerable distress to some fishing industries, social disruption, and financial losses. Although no species are known yet to have become totally extinct as a result of this fishing pressure, the adverse effects will in some cases endure for many years and some may be irreversible. Over the same period, shifts in the nature of interest in the marine resources have reminded us that values can and do change, often unpredictably. Thus, wise use of resources involves regulating the impact of current exploitation so as to provide for continuation of current types of use but at the same time not to foreclose use of the resource for other purposes in the future. This is particularly desirable for a resource the exploitation of which is regulated internationally, because those who use it in the future may not always be the descendents of those who use it now. Application of Subparagraph 2 is a necessary—but not in itself sufficient—action to preserve options. This will be achieved generally by limiting the impact of fishing, and probably more effectively by encouraging a pattern of resource utilization such that a given total yield is secured as a balanced mixture of species from various trophic levels[1] in the ecosystem, rather than comprising one or a few species taken mainly or entirely from one trophic level.

As pointed out earlier, simultaneous fulfillment of all criteria laid down in the three subparagraphs may in practice involve some compromise, but should by its nature give compensatory benefits. In particular, by taking yields on a continuing basis at levels somewhat less than the maximum possible, some unintended wasteful expenditure of other natural resources used by fishery industries (e.g., fuel used to obtain the catch or materials and energy used in constructing excess vessels and gear), will be avoided, and the net benefits accruing to each participant in the fishery will often be increased. The problem of wasteful use of other resources is addressed in Subparagraph 1 of Paragraph B in the Annex. It has long been recognized that the benefits of conservation may lie as much in avoiding excessive fishing effort, as in enhancing the value of sustained catches. Application of the Principles embodied in the definition of conservation would of course restrain effort, but it is not alone sufficient; there are numerous cases where the benefits from conservation measures have been largely dissipated through intensified competition among participants for shares of the regulated catches. At a time when it is becoming widely accepted that there are overall limits to natural resources, it seems appropriate that the instruments of the United Nations Conference on the Law of the Sea should be explicit on this matter by recognizing that the conservation of living marine resources while having special aspects, is nevertheless a part of the general problem of resource husbandry.

Subparagraph 2 may be read to cover also the need to act, in the process of applying conservation measures, so as to ensure that catches of fishes and other animals that may be taken incidentally with those most prized, are not wasted.

While some ecological concepts are rather well founded and generally accepted by the scientific community, there are weaknesses in current theory, data, models, and analytical and computational procedures. Furthermore, as fishing continues to intensify and diversify, the nature of its impact is changing so that, notwithstanding scientific advances of the past two decades, we are still far from being able to predict in detail, or at long-range, changes in marine ecosystems—particularly qualitative changes—that may profoundly affect man's use of those resources. Furthermore, although the machinery for decision making may be improved; there will always be some delay in implementing decisions, some likelihood of mistakes having significant consequences, and perhaps some shortcomings in enforcement of regulations. Good management calls for appropriate allowance for these inevitabilities. Again, natural changes in many characteristics of living systems and of their physical environment cannot yet be predicted, and some may never be predictable. These facts all call for the inclusion of safety factors in conservation measures, the margin of safety provided being based on reasonable assessments of the degree of uncertainty and the magnitude of the risk. This is provided for in Paragraph B, Subparagraph 2.

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[1] This biological term describes the feeding relationships of organisms. Some—the green plants, including phytoplankton—are primary producers, constructing living material from inorganic nutrients in the sea by photosynthesis; others are herbivorous; primary carnivores feed on the herbivores, and they in turn form the diet of secondary carnivores. These several categories (producers, herbivores, primary carnivors, etc.) constitute trophic levels.

The wording of Subparagraph 3 is taken straight from the 1958 Convention. It favors a priority of resource use that is now even more relevant than it was in 1958, or than in 1966 when that convention came into force. The wording does not, in our interpretation, exclude products for indirect human consumption, but would nevertheless tend to favor direct use where possible. Since that time, some other aspects of "product quality" have also been recognized as important, such as the presence of heavy metals, pesticides, and other contaminants in marine organisms. This is in part covered by other draft articles before the United Nations Conference on the Law of the Sea that deal with pollution of the sea, but perhaps calls for explicit cross-reference in the articles on conservation and allocation of fisheries resources.

The 1958 Convention provides for conservation measures to be based on scientific evidence. This is a necessary, but not a sufficient, provision for successful application of new international law. Data must not only be adequate, but they and the derived results must be promptly disseminated so that critical review of them is possible. The application of conservation measures should be constantly modulated by feedback of data, and their effects continuously monitored. Furthermore, pertinent environmental properties need to be monitored concurrently, and the observed or anticipated effects of changes in them—whether natural or caused by man—taken into account through appropriate changes in the conservation measures.

A most important need is to locate unambiguously the responsibility for collecting and analyzing data, and generally for conducting research and monitoring. Practical considerations dictate that specific duties must be firmly, though not necessarily exclusively, assigned to those entities that have the right to utilize the resources, and particularly to those that exercise that right. Not only can they benefit economically from their right, but much of the data essential for the formulation of conservation measures comes from the catches and the records of fishing operations. Those who utilize a resource are, further, likely to be the ones with the means, or access to the means, to conduct the necessary research, and also with the possibilities, under international law, of conducting certain kinds of research—whether from commercial or research vessels or from other platforms—in areas over which jurisdiction is exercised. One of the main causes of past failures has been that data have not been promptly available, nor contributed by all participants in the fisheries, and have not always been of adequate scope. Furthermore, the means to analyze and interpret the data and materials that have been collected have frequently been inadequate, and the results have not been promptly disseminated. The provisions of Paragraph B are intended to correct those faults.

ANNEX

A. "Conservation of the living re-
(a) sources of the sea is that aggregate

of measures required to maintain those resources and their environment in a state such that

(b) (1) a maximum and stable supply of food and other marine products may be taken from them on a continuing basis;
(c) (2) there is minimal likelihood
(d)(e) of irreversible or long-term adverse effects of exploitation on particular resources or on the marine ecosystem as a whole; and
(3) a wide diversity of options for future use is ensured."

B. "Conservation measures shall be formulated with a view to

(f) (1) avoiding wasteful use of other natural resources expended to secure the supply of food and other marine products;
(2) providing a margin of safety to allow for unpredicted variations and characteristics of marine resources and their environment, and for the fact that the application of measures may be subject to delay or be otherwise imperfect; and
(3) securing in the first place a supply of food for human consumption."

C. "The party or parties having jurisdiction over a living marine resource shall ensure that such continuing scientific research is conducted, and that such data are regularly collected and analyzed and results promptly disseminated, as are necessary for the formulation of conservation measures and for monitoring the effects of their application. The scope of the necessary research and data is such as to reveal the state and dynamics of the stocks being or to be exploited, the effects of exploitation on them, their interactions with other elements of the marine ecosystem to which they belong, and their dependence on environmental processes."

"In meeting this responsibility the party having jurisdiction shall ensure that entities acting under its authority collect the necessary data, including information about the utilized and the discarded
(g) catches, and about the fishing op-
(h) erations."

Notes

(a) The 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas refers in its Article 1, Paragraph 2, to "conservation" as the process of reaching a defined state of the resources. Article 2, on the other hand, defines "conservation" as "the aggregate of measures" required for attainment of such a state. Here, the latter approach is followed, for convenience.

(b) We would have preferred not to use the technical term "maximum" in such a text but recognize that it has found acceptance in many international treaties as a legal term [see (e) below].

(c) Values may be attached to properties of living marine resources other than their ability to yield "food and products"; examples are the recreational value of sport fishing, and aesthetic, ecological, and scientific values. Under present conditions, these other values pertain more to resources that are, or may become, under the exclusive jurisdiction of certain coastal states than to resources of international interest; for the latter, that are the primary concern of the draft here offered, we retain the overriding interest in "products," noting that possible shifts of interests are taken care of in Subparagraph 3.

(d) Irreversible effects include the extinction of species, tribes, or races of plants or animals, or the reduction of them to levels from which they may not recover their former order of abundance even if exploitation of them were to cease entirely. The term also includes any irreversible consequences of such a reduction to other components of the ecosystem. This criterion can strictly only be expressed in terms of a change in a probability. There are now available (as there were not in 1958) case histories and some biological models relevant to this criterion, adoption of which would ensure that the danger was recognized and due caution exercised.

(e) Whereas the concept of maximum sustainable yield in the 1958 Convention was formulated as a sufficient criterion of conservation, a cohesive set of criteria is now required. The 1958 formulation becomes, as amended, one of the set. Different elements of such a set may be only partially compatible. From the scientific point of view, several interconnected variables cannot, in general, simultaneously be maximized or minimized. Such incongruity is, however, not uncommon in legal documents, and the practice has been followed here, rather than attempting to define precisely the mathematical conditions for singular states.

(f) The set of desirable qualities to be maintained in the resource can be expanded to meet economic and social criteria other than those recognized explicitly in the definition of conservation. Not all of them will necessarily be fully compatible with the three contained in the definition. They concern, inter alia, the relations of input to output of the industry and its continuity and stability; and the nature and quality of the products. Input–output relations can be expressed formally in the language of economic theory, but for the present purposes, especially in an international context, a more general reference to the ways of using some natural resources to secure values from others seems more appropriate. (Subparagraph 1). This consideration might also be taken into account in the application of the provision of Subparagraph 3.

(g) Data concerning quantities, composition, and other characteristics of catches are among the most important information required for resource assessment. Most catches are retained and utilized, but frequently parts of the catches are discarded. Such discards may include unwanted catches of valued species—undersized ones, for example—or other species of lower market value or for which there is no market. It is always desirable and sometimes essential, to have information about them, for monitoring the effect of certain conservation measures, for assessing the overall impact of fishing, for studying how resource waste might be avoided, and because in the future species now discarded may be valued more highly than now.

(h) Notwithstanding the recent development of some independent methods of assessing marine fishery resources, measures of "fishing effort" remain essential for this purpose. In any case, appropriate conservation resources can neither be formulated nor their effects adequately monitored without a rather detailed knowledge of the intensity, efficiency, and deployment of fishing operations. Data needed include the distribution of different kinds of fishing effort in time and space, and information about technical, environmental, and other factors that determine the level of performance of fishing units.

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